CARBON-NITROGEN RATIOS OF GRASS MULCHES

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Introduction

This facilitating study was undertaken in 1946 at the Albuquerque Soil Conservation Service Nursery near Bernalillo, New Mexico to determine: (1) the effect of continuous grass cover as compared with continuous clean cultivation on the carbon-nitrogen ratio of surface soils; (2) the carbon-nitrogen ratio of various grasses in order to estimate their value as a source of organic matter if turned under and the subsequent need for additional nitrogen fertilizer; (3) the value of burning versus turning under grass mulches for grass seed production. Such information would aid in making an estimate of the effect of grass mulches upon future nitrogen requirements.

Description of Area and Methods

History: This study was carried out in 6 fields in grass seed production which are numbered 2, 3, 4, 8, 12 and 13, one in clover seed production, field 1, and one in tree seedling production, field 10. They were old cultivated fields except fields 10 and 12 which were subjugated from cottonwood bosque in 1936, and field 8 which was subjugated from range in 1937. Prior to the establishment of the grasses now present fields 3, 4, and 13 were in nursery stock, field 8 was in alkali sacaton, field 12 in sideoats grama and fields 2 and 3 in miscellaneous grasses. Prior to the establishment of ladino and red clover, nursery stock was grown in field 1. Since there have been variations in fertilizer treatment in these fields, the numbers of the borders are also given.

A combine is used to harvest the grass seed. Thus both the tops and stubble are left on the field. The stubble is mowed flat the following spring. To date, the heaviest mulch has developed on field 3. In February, 1946, this weeping lovegrass mulch was estimated to weigh 5.5 tons per acre on an air dry basis. In order to reduce excessive water use in this field, the north half (including border 5) was heavily burned in March 1946. All of the fields in grass seed and clover seed production are border irrigated.

Tree seedlings have been raised in the sprinkling system borders, field 10, since the area was subjugated in 1936 from cottonwood bosque. Row crops of tree seedlings have been grown continuously in this field with the following exceptions. Cover crops of sweet clover were turned under in 1942 on border B5* and in 1945 on the north half, B5N. The south half of border B5, (B5S) and A9N were fallow in 1945. In 1945, 2000 and 1000 pounds per acre of sulfur were applied to B5 and A9N respectively. In 1946, 2000 pounds per acre of sulfur were applied to both B3S and A6N. In an effort to improve the soil structure, tall wheatgrass and weeping lovegrass

*In this field a roadway separates borders designated as A and B respectively.

were planted in B3 and A6N respectively.

Chemical Methods: The analyses were made by James Thorne, Soil Scientist, at the Soil Conservation Service Cooperative Soils Laboratory, Utah State Agricultural Experiment Station, Logan, Utah. The organic carbon was calculated by subtracting the inorganic carbon from the total carbon. The former was determined by direct combustion, absorption and weighing of the evolved carbon dioxide. The inorganic carbon was determined gasometrically using the Parr apparatus. Total nitrogen was determined using the Kjeldahl method. The organic matter content was determined also using the regular laboratory wet oxidation method. These organic matter values were converted to organic carbon in order to compare with those obtained from dry combustion. In general, the two methods compare favorably, the maximum deviation being 0.20%.

Carbon-Nitrogen Ratios

Mulch: Soils literature abounds with references reporting decreased crop yields following the turning under of wheat straw and timothy sod, both of which have wide carbon-nitrogen ratios. Pinck, Allison and Gaddy (1) reviewed the literature pertaining to the amount of nitrogen required to rot materials of wide carbon-nitrogen ratios. They reported that the critical carbon-nitrogen raties for wheat straw under summer conditions were 27 to 31.

As a conservative figure, it would appear necessary to apply enough nitrogen to reduce the C:N ratio to 25. Thus the mulch on field 3-11 (Table 1) would require 16 pounds more nitrogen per ton of oven dry mulch. Assuming the oven dry weight of this mulch to be four tons per acre, 320 pounds per acre of ammonium sulfate should be applied to insure proper decomposition of the portion above ground. On the other hand, if this mulch were to be burned, the total loss of nitrogen from four tons of mulch would be equivalent to 235 pounds per acre of ammonium sulfate.

In August, 1946, the highest carbon-nitrogen ratio, 80, was found in the unfertilized mulch of weeping lovegrass, field 8-15. Conversely, the lowest C:N ratio, 43, was found in the same field, 8-18, on the most heavily fertilized border at the Nursery (Table 1). This border received the equivalent of 1600 pounds of ammonium sulfate per acre between March, 1945, and April, 1946. In field 3, the weeping lovegrass mulch from four seasons had a C:N ratio of 58 which had received the equivalent of 1200 pounds of ammonium sulfate.

A study of the nitrogen fertilized grass mulch data for sand lovegrass and tall wheatgrass shows that the C:N ratios are slightly higher than those of weeping lovegrass and sideoats grama (Table 1). On the other hand, only sand lovegrass mulch had an appreciably higher requirement for additional nitrogen assuming that a C:N ratio of 25 is necessary for satisfactory decomposition of grass mulches.

Table 1. Summary of organic matter and carbon-nitrogen ratios of grass mulches[a], August 22, 1946 - Albuquerque Nursery.

Field Border	Grass	Planting Date	Nitrogen applied 1945 lbs./acre	Nitrogen applied 1946 lbs./acre	Organic carbon lbs./ton	Total nitrogen lbs./ton	C:N ratio	Nitrogen required[b] lbs./ton
3-5	Weeping lovegrass hay	1942	105	80	764	10.9	70	20
3-11	Weeping lovegrass mulch	1942	160	80	692	11.8	58	16
8-15	Weeping lovegrass mulch	1942	0	0	600	7.5	80	16
8-18	Weeping lovegrass mulch	1942	160	160	562	13.0	43	9
4-2	Sideoats grama mulch	1941	120	160	628	10.7	59	14
2-7	Tall wheatgrass mulch	1943	0	120	520	7.1	73	14
12-5	Sand lovegrass mulch	1944	60	80	676	9.6	71	19

a. The word mulch is used herein to indicate grass grown prior to 1946.
b. Additional nitrogen required per ton of oven dry mulch to properly rot it at a carbon-nitrogen ratio of 25.

It is well known that the percentage of total nitrogen declines with maturity. Nitrogen fertilized weeping lovegrass, sand lovegrass, tall wheatgrass and sideoats grama contained from three to five times more nitrogen on a percentage basis immediately prior to heading than in the mulch (Table 2). This decline in percentage of total nitrogen appears in part to be related to the increase in stems. For example, in field 3, on June 20, 1945, the weeping lovegrass had headed out. At this time the average total nitrogen content of the leaves and stems were 1.8% and 0.8% respectively. If the primary concern was to turn under a mulch with a favorable carbon-nitrogen ratio, then the grasses studied should be cut prior to heading out.

Soil: Composite soil samples, 0-10" were collected from fields which had been in grass seed production from 5 to 10 years in order to determine the effect of dead grass roots. It seemed probable from the work of other investigators that the weight of dead grass roots might be a ton or more per acre in old stands. Weaver and Fink (4) reported that only 14% of the roots of sideoats grama lived three growing seasons. When a heavy sod is turned under it would appear that the roots might weigh several tons. In Nebraska after three seasons of growth, the roots of big bluestem, little bluestem, and blue grama weighed 5.5, 2.7, and 1.6 tons per acre respectively. (3).

Table 2. Total nitrogen in grasses immediately prior to heading and in mulch, grass seed production. Albuquerque Nursery.

Grass	Field Border	Total Nitrogen Grass %	Total Nitrogen Mulch %	Age of Mulch Years
Weeping lovegrass	3-5	1.7	0.5	0 (hay)
Weeping lovegrass	3-11		0.6	4
Weeping lovegrass	8-15		0.4	4
Weeping lovegrass	8-13	1.6	0.6	4
Sideoats grama	4-2	1.5	0.5	5
Tall wheatgrass	2-7	2.0	0.4	2
Sand lovegrass	12-5	1.9	0.5	1
Big bluegrass	3-8 & 11	1.6		

Nevertheless, the C:N ratios of surface soils in continuous grass for a period of from 5 to 10 years had ratios varying from 11 to 14 (Table 3). The textures ranged from a sandy loam to a clay. In field 8 the C:N ratio was 12 from both an unfertilized check and a border which had received the equivalent of 1600 pounds of ammonium sulfate in two seasons. The C:N ratios of the surface soils under weeping lovegrass, sand lovegrass, tall wheatgrass and sideoats grama were similar. In these fields C:N ratios varying from 11 to 14 would appear to be favorable for the proper decomposition of grass roots.

Since it was thought that the C:N ratios of soils in long time grass seed production might be lowered by including a legume in the rotation, composite soil samples were taken from borders in field 1 planted to ladino and red clover. The C:N ratios of the surface soils from the former and latter were 10 and 11 respectively. Since these values are only slightly lower than those in grass seed production, it does not appear to be necessary to include a legume in the grass seed rotation.

Composite soil samples from the sprinkling system borders in field 10 which had been clean cultivated had the highest carbon-nitrogen ratios varying from 13 to 21. Borders A2N and A6N have been clean cultivated for 10 seasons. The carbon-nitrogen ratios were the lowest in these borders, but they were as high as any field in grass seed production. The highest C:N ratios, 21, were found in B3 and B5, both of which had a cover crop of sweet clover in 1942 and an application of pine bark sludge in 1945. In 1945, a heavy crop of Hubam clover was turned under on B5N and the south half was fallow. The C:N ratios were identical, 21. On the other hand, tests for nitrates in May, August, and October 1945, indicated that the soil was well supplied in B5N but became deficient in B5S in October. These results indicate that even with the widest carbon-nitrogen ratios found, there is still a supply of available nitrates during the growing season.

Table 3. Summary of organic matter and carbon-nitrogen ratios of surface soils 0-10" at Albuquerque Nursery, August 22, 1946.

Field & Border Nos.	Crop	Seasons in Grass	Texture Class[a]	Organic Matter %	Organic Carbon %	Total Nitrogen %	Carbon Nitrogen ratio
Border irrigated:							
3-5	Weeping lovegrass	5	1	2.1	1.25	0.099	12
3-11	" "	5	1	1.4	0.86	0.075	11
8-15	" "	10	2	1.4	0.80	0.065	12
8-18	" "	10	2	1.4	0.80	0.067	12
4-2	Sideoats grama	3	2	1.4	0.80	0.064	12
2-7	Tall wheatgrass	7	1	1.9	1.07	0.092	12
13W	" "	6	1	1.8	0.91	0.079	12
13E	" "	6	3	1.4	0.85	0.062	14
12-5	Sand lovegrass	7	3	1.1	0.61	0.046	13
1-1	Ladino clover	0	2	1.8	0.95	0.095	10
1-3	Red clover	0	2	2.0	1.10	0.101	11
Sprinkling system:							
B3N	Tall wheatgrass	1	3	1.1	0.81	0.038	21
B3S	" "	1	3	1.5	0.86	0.049	18
B5N	Chinese elm	0	3	1.9	1.31	0.062	21
B5S	" "	0	3	2.1	1.31	0.063	21
A6N	Weeping lovegrass	1	3	1.0	0.48	0.035	14
A9N	American elm	0	3	1.2	0.60	0.047	13

a Classes 1, 2, and 3 are heavy, moderately heavy and medium textured soils.

Application of Results

Grass seed production: In order to insure proper decomposition of weeping lovegrass, sand lovegrass, sideoats grama, and tall wheatgrass mulches, from 15 to 20 pounds of nitrogen should be applied per ton of oven dry mulch prior to plowing under. This amount is somewhat in excess of the amount required for a C:N ratio of 25, however, a large quantity of dead roots will also be decomposing.

Although the nitrogen contained in the mulch will be slowly released later (1) there is little assurance that the nitrogen fertilizer requirements for grass seed production will be materially reduced. For high yields of grass seed, large amounts of nitrates appear to be required in the grasses several weeks prior to heading. When a field of grass is plowed up, usually in late summer, it is not replanted until the following year. This allows time for the sods to be broken up and a good seed bed prepared. During this period rapid nitrification of the incorporated nitrogen fertilized grass mulch would be expected providing moisture conditions are suitable. Since the grass would not be planted until the following summer, part of the nitrate nitrogen would be gradually converted to organic nitrogen by the soil organisms. Most of the remaining nitrate nitrogen and part of the ammonia would be leached from the soil by the several closely spaced irrigations required in the establishment of new

grass seedlings. Thus there seems to be little chance that large amounts of nitrates will be present when needed in grass seed production unless added as commercial fertilizers. The addition of nitrogen to the incorporated grass mulch should increase the humus content (2), the base exchange capacity, the availability of certain elements, and improve the soil structure. With current practices there is very little ammonia and nitrates in the soil after harvesting. However, some of the humus will gradually decompose into nitrates and more food reserves might be stored by grasses after harvesting during the growing period remaining, if a higher humus level is maintained. More vigorous plants may result from the incorporation of grass mulches with nitrogen. Somewhat higher yields of grass seed might be expected if the heavy rates of nitrogenous fertilizers are continued.

Since the infiltration rates in fields 2, 3, 4, 12, and 13 are high, the heavy mulch might be burned until one or two years prior to plowing. Thus, excessive water use would be reduced, yields increased and less nitrogen would be required for the smaller amount of mulch when it is turned under. In field 8, the mulch is needed to increase infiltration in incipient black alkali areas.

Tree seedling production: In field 10, tall wheatgrass, weeping lovegrass and alta fescue are being grown in certain borders to improve soil structure. If these grasses were clipped when small and the mulch allowed to remain, a mulch with a low C:N ratio would result. On the other hand the incorporation of green manure crops in field 10 has not increased tree growth. Since soil structure is reported to be improved by alternate wetting and drying and by large numbers of grass roots, it appears logical to cut the grasses for hay just after heading.

Summary

1. C:N ratios varied from 11 to 14 in surface soils which were in continuous grass seed production for periods varying from 5 to 10 years. Such ratios are not expected to cause an increase in future nitrogen requirements for grass seed production.

2. The highest C:N ratio, 80, occurred in an unfertilized weeping lovegrass mulch. The lowest C:N ratio, 43, occurred in the same field but on a border which had received the equivalent of 1600 pounds per acre of ammonium sulfate in the previous 17 months.

3. Assuming that a C:N ratio of 25 is required for satisfactory decomposition of grass mulches, from 15 to 20 pounds of nitrogen should be added per ton of oven dry mulch when it is incorporated into the soil. Sand lovegrass mulch appears to require more nitrogen than mulches from tall wheatgrass, weeping lovegrass and sideoats grama.

4. Grass mulches weighing several tons per acre have resulted in uneven ripening of grass seed, excessive water use and loss of nitrates. Under these conditions and when it is not feasible to incorporate the mulch into the soil, burning may be economically desirable to increase grass seed production.

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